United States Patent

Busby

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[54] **GLASS FURNACES**

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[73] Assignee: **National Research Development Corporation**

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[52] **U.S. Cl.** ..... **263/40 R**, 65/347

[51] **Int. Cl.** **F27b 3/00**

[58] **Field of Search** ..... 263/40 R, 43; 65/347

[56] **References Cited**

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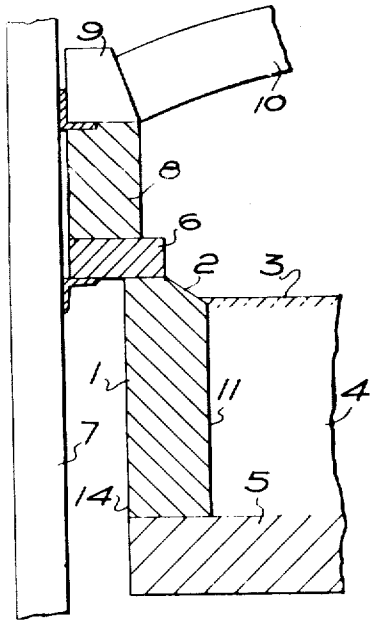
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[57] **ABSTRACT**

A glass furnace having its side walls chamfered at the top within the range of more than 30° to 45° to the horizontal from their inner vertical face over a substantial portion of the width of the top of the walls, whereby the resultant chamfered surface includes the flux line when the furnace is in use.

8 Claims, 8 Drawing Figures



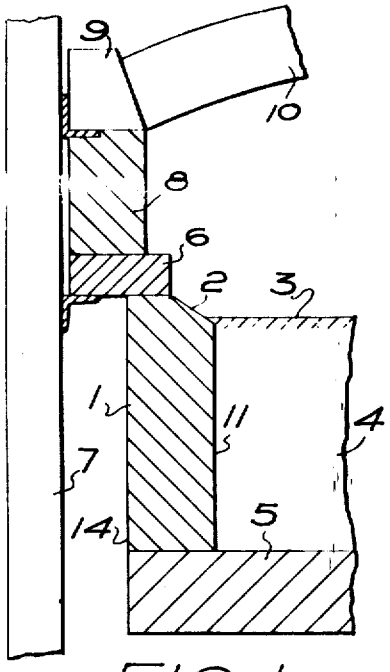


FIG. 1

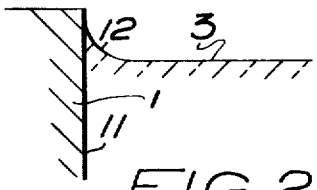


FIG 2

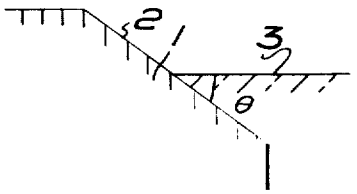


FIG 3

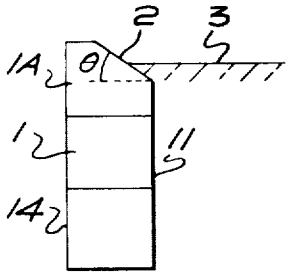


FIG 4

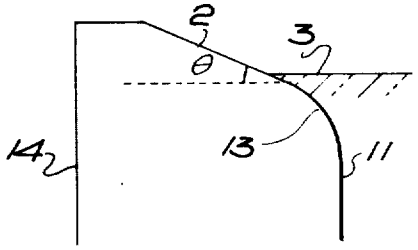


FIG. 5

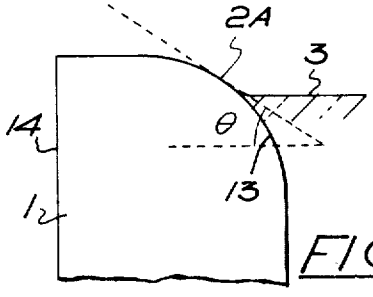


FIG.6

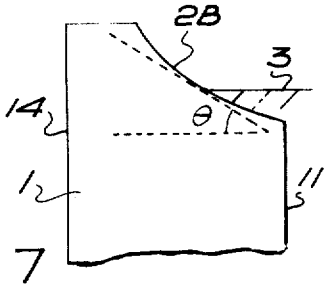


FIG. 7

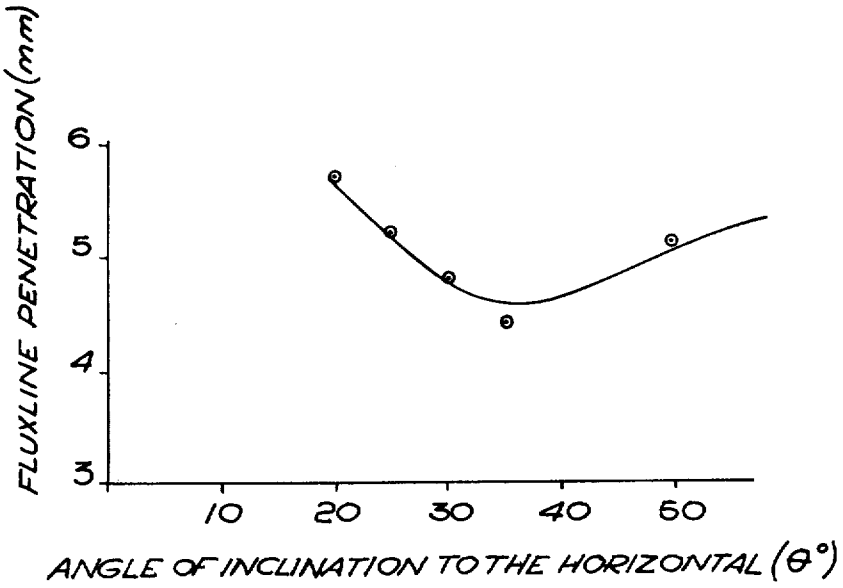

FLUXLINE PENETRATION (mm)
6
5
4
3
10
20
30
40
50
ANGLE OF INCLINATION TO THE HORIZONTAL (θ°)

FIG.8

GLASS FURNACES

This invention relates to glass furnaces and is concerned with diminution of the wear that takes place in the glass tank sides, and notably at the level of the top of the bath of molten glass, viz., along what is known as the "flux line." This lies near the top of the inner vertical face of the sides, and the corrosion of the refractory along the flux line is very severe, and much more severe than the wear lower down the sides. The operation life of the tank sides is therefore governed by the rate of wear along the top. In the case of tank sides made of fusion-cast blocks the full height of the sides, the blocks find themselves in need of replacement solely because of the wear along the top, even though the more deeply submerged part of the blocks has suffered so little wear that that part of the blocks could have remained in use for a considerably longer period. In the case of tank sides made from coursed blocks, the flux line is along the uppermost course of blocks, so that it is this course that is subjected to the very severe corrosion.

Many theories have been propounded in connection with the flux line corrosion, but such theories as those based on the existence of density currents in the bath and temperature gradients through the depth of the bath do not provide a satisfactory answer to the problem of what really causes the localized attack, and palliatives based on the various theories have not succeeded in materially diminishing the strength of the attack much less in eliminating the attack altogether.

According to the present invention, the side walls of a glass furnace are chamfered at the top within the range of more than 30° to 45° to the horizontal from their inner vertical face over a substantial portion of the width of the top of the walls, whereby the resultant chamfered surface includes the flux line when the furnace is in use. In other words, instead of the top surface of the glass making contact with a wall surface at right-angles to it, as with the usual vertically faced tank sides (and still substantially at right-angles after such sides have suffered wear following the initiation of flux line attack), the top surface of the glass contacts a wall surface that inclines upwardly away from it. As a result, the surface tension and gravity forces along the flux line tend to balance each other, with the result that the meniscus of the liquid glass virtually disappears, the surface therefore remaining horizontal to its line of contact with the inclined surface along the top of the tank sides.

It is believed that the existance of a meniscus is directly responsible for flux line corrosion, probably because a stirring action is set up in the meniscus, located where the furnace atmosphere contacts both the top surface of the bath and the vertical surface of the side wall. Such stirring action leads to an increase in the rate of solution of the refractory of the wall in the glass, by disturbance of the thin glass film that forms a diffusion layer of what is a diffusion-controlled process, and the dynamic situation set up by the solution process is itself favorable to the perpetuation of the process. By substantially eliminating the meniscus, the invention provides conditions where there is no thin glass film across which a surface tension gradient would develop, and thus minimizes the stirring action that is believed to be conducive to solution of the refractory in the glass.

The appropriate inclination of the chamfered top of the side wall may vary with different glass compositions, in accordance with their surface tension values. Thus, with typical soda-lime container glass, the rate of wear at a glass temperature of about 1,450° (surface tension: 290 dynes/cm.) progressively diminishes towards the middle of the above indicated range of 30° to 50° inclination, with a notable reduction in the rate of wear to some 20 to 30 percent less than the wear on a vertical face, when the inclination is 30° to 45°.

With E-glass, as used for making glass fibers that are particularly suitable to provide good electrical insulation, the rate of wear at a glass temperature of about 1,400° C. (surface tension: 340 dynes/cm) likewise diminishes in the 30° to 50° inclination range, with the most noticeable reduction (10 to 20 percent) being when the inclination is 30° to 40°.

With both types of glass referred to above, it was found that optimum wear resistance at the flux line occurred with an inclination of 35° to the horizontal.

With the development of a meniscus of molten glass kept to a minimum, the onset of attack on the refractory wall is delayed, and the attack that does occur proceeds slowly, as compared with that on a vertical inner face.

The top-chamfered side wall may be a fusion-cast block the full depth of the tank, or the wall may be courses of blocks, the depth of the chamfering at the inner face being less than the depth of the blocks in the top course.

The chamfering may consist of a plane face, extending over say three-quarters of the 10 inch or 12 inch thickness of the wall, or it may only approximate to a plane, as by being somewhat convex or concave in cross-section, and in either case possibly rounded into the inner and upper faces of the wall.

The invention will now be further described with reference to the accompanying drawings, in which:

FIG. 1 is a vertical section through one side of the tank of a glass furnace, with a block forming the full height of the side wall and chamfered at the top:

FIG. 2 is a diagram showing the meniscus formed where the surface of the molten glass meets the side wall with a vertical face;

FIG. 3 is a diagram showing the absence of a meniscus when the surface of the molten glass meets an inclined surface in accordance with the invention;

FIG. 4 shows a side wall formed from courses of bricks, the top course being plane chamfered;

FIG. 5 shows a plane chamfer rounded to the inner face of the side wall;

FIG. 6 shows a convex chamfer rounded to the inner face of the side wall;

FIG. 7 shows a concave chamfer; and

FIG. 8 is a graph representing the effect of the angle of inclination on flux line corrosion in respect of soda-lime-silica glass.

In FIG. 1 is shown a typical section of one side of the tank of a glass furnace having a full-height block construction for its side wall, except that the top of the block is chamfered at 2, so that the surface 3 of the molten glass 4 meets the chamfered surface 2. The side wall 1 rests on a siege 5; a tuck stone 6 supported from the buckstay 7 overlaps the side wall to the start of the surface 2, and is surmounted by a breast wall 8, above

which is a skew back **9**, also supported from the buckstay, from which the crown **10** springs.

When, as shown in FIG. **2**, the glass surface meets a vertical inner face **11** of a side wall **1**, a meniscus **12** is formed at the flux line and it is here that wear takes place, possibly for the reason already explained. However, if the top of the side wall **1** is chamfered at an angle θ to the horizontal, within the range 30° to 50°, as shown in FIG. **3**, the surface **3** no longer forms a meniscus where it meets the chamfered surface **2**.

The chamfered surface **2** may be formed at the top of a full-height block construction as in FIG. **1**, or it may be formed in the top course **1A** of a side wall as in FIG. **4**. In FIGS. **1** and **4**, the chamfered surface **2** is plane, and as shown by FIG. **5**, such a plane surface **2** may be rounded at **13** into the inner face **11** of the side wall.

In FIG. **6**, a convexly chamfered surface **2A** is provided, with the required inclination θ represented by the plane tangent to the surface where it is met by the glass surface **3**. As in FIG. **5**, the surface is rounded at **13** into the inner face **11**.

In FIG. **7**, a concavely chamfered surface **2B** is provided, with the required angle θ again represented by the plane tangent to the surface where it is met by the glass surface **3**.

In FIGS. **1** and **4** to **7**, the surface **2** (or **2A** or **2B**) extends over a substantial width of the top face of the side wall **1**, in fact over most of the width of the face, the remainder of the face being overlapped by the tuck stone **6** as in FIG. **1**.

As is shown graphically in FIG. **8**, the rate of wear at a glass temperature of 1,450° C. progressively diminishes as the angle of inclination of the sloping face of the top block approaches 30° to the horizontal, with a notable reduction in the rate of wear to some 20 to 30 percent less than the wear on a vertical face, when the inclination is 30° to 45°, with an optimum of 35°.

What I claim is:

1. A glass furnace having its side walls chamfered at the top within the range of more than 30° to 45° to the horizontal from their inner vertical face over a substantial portion of the width of the top walls, the resultant chamfered surface including the flux line when the furnace is in use.

2. A glass furnace as in claim **1**, wherein the side walls are chamfered at the top within the range of more than 30° to 40° to the horizontal.

3. A glass furnace as in claim **1**, wherein the side walls are chamfered at the top at substantially 35° to the horizontal.

4. A glass furnace as in claim **1**, having a full-height block construction for its side walls, the chamfering being at the top of the block.

5. A glass furnace as in claim **1**, having a coursed construction for its side walls, the chamfering being provided in the top course.

6. A glass furnace as in claim **1**, wherein the chamfered surface is plane.

7. A glass furnace as in claim **1**, wherein the chamfered surface is convex, the tangent at any point on the convex surface lying within the range of more than 30° to 45° to the horizontal.

8. A glass furnace as in claim **1**, wherein the chamfered surface is concave, the tangent at any point on the concave surface lying within the range of more than 30° to 45° to the horizontal.

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